Comparison of OMI Cloud Pressures Derived from Rotational Raman Scattering with Collocated MODIS Data

Alexander Vasilkov[1] and Joanna Joiner[2]

[1]Science Systems and Applications, Inc.

[2]NASA/Goddard Space Flight Center

Aura Validation Meeting
Aerosol/Cloud/SO2 Subgroup, 21 September 2005

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- Validation the cloud pressure retrievals with MODIS data. Focusing on
  - Tropical storm Arlene
  - Hurricane Katrina
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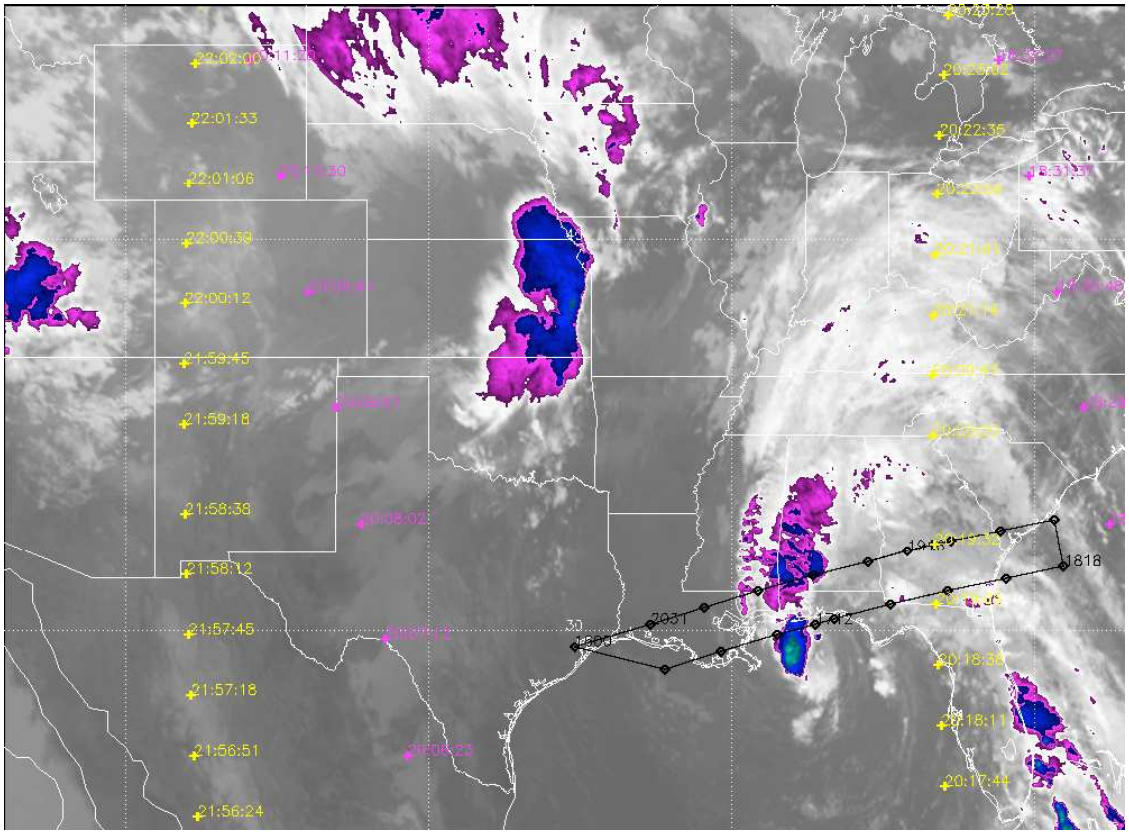
Algorithm Basics

- Effective ("scattering") cloud pressure derived from fitting the high-frequency structure caused by filling-in of solar Fraunhofer lines due to rotational Raman scattering (RRS) in the atmosphere (one of two OMI cloud pressure algorithms-other from O_2-O_2 absorption band)
  - "scattering" cloud pressure refers to a pressure level reached by back-scattered photons averaged over a weighting function
- Use the Mixed Lambert-Equivalent Reflectivity (MLER) with the fixed ground (clear-sky) and cloud reflectivities R_{clr}=0.11 and R_{cld}=0.4
- Use the spectral window of 392-398 nm
- Linear with wavelength term to remove atmospheric scattering and surface reflection effects
- Wavelength shift term
- Soft calibration based on an analysis of residuals (Observed minus Calculated radiances) over snow/ice scenes

Data Used in the Study

- OMI data for two events: tropical storm Arlene (orbit 4827 of Jun. 11, 2005) and hurricane Katrina (orbit 5963 of Aug. 28, 2005).
- MODIS L2 cloud data collected over the regions of Arlene and Katrina
- MODIS cloud-top pressures from the IR window and MODIS cirrus reflectance from 1.37 μm channel were collocated to OMI pixels
- Comparisons OMI RRS cloud pressures with MODIS cloud-top pressures were mostly done for high altitude clouds

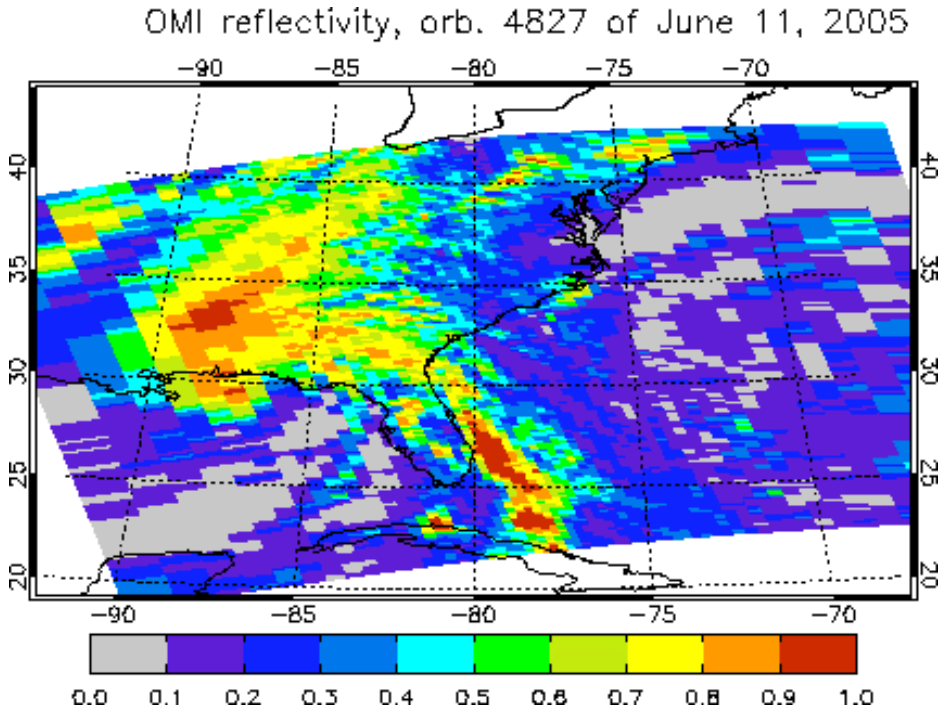
Tropical Storm Arlene (June 11, 2005)

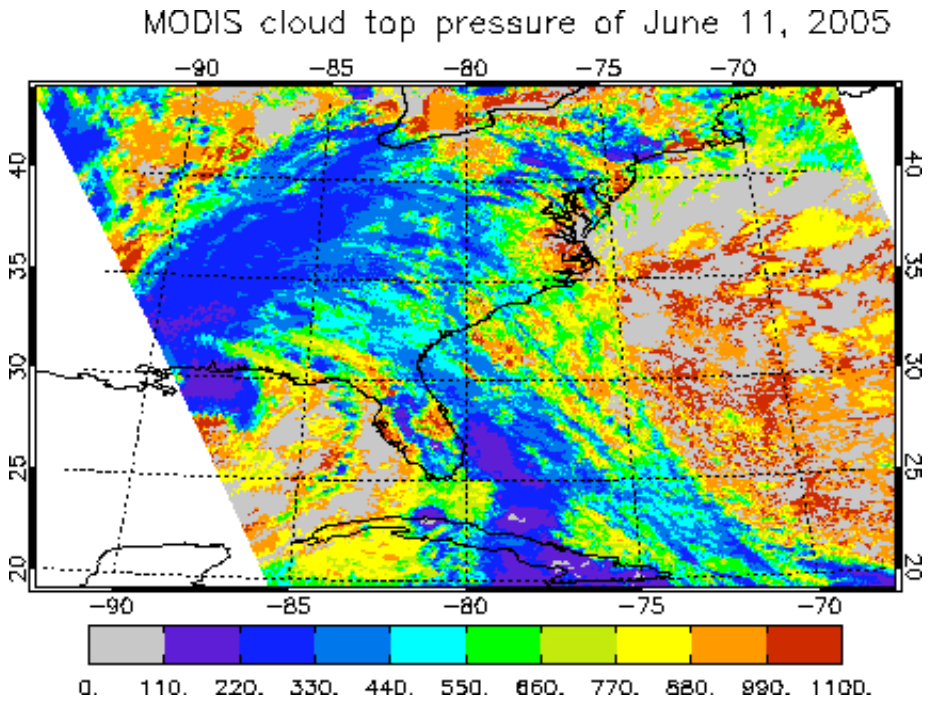


GOES IR image with the AVE WB-57 track overlayed

Blues/purples show the higher clouds (30,000-40,000 feet). The Aura sub-orbital points are in magenta. CPL did not operate this day.

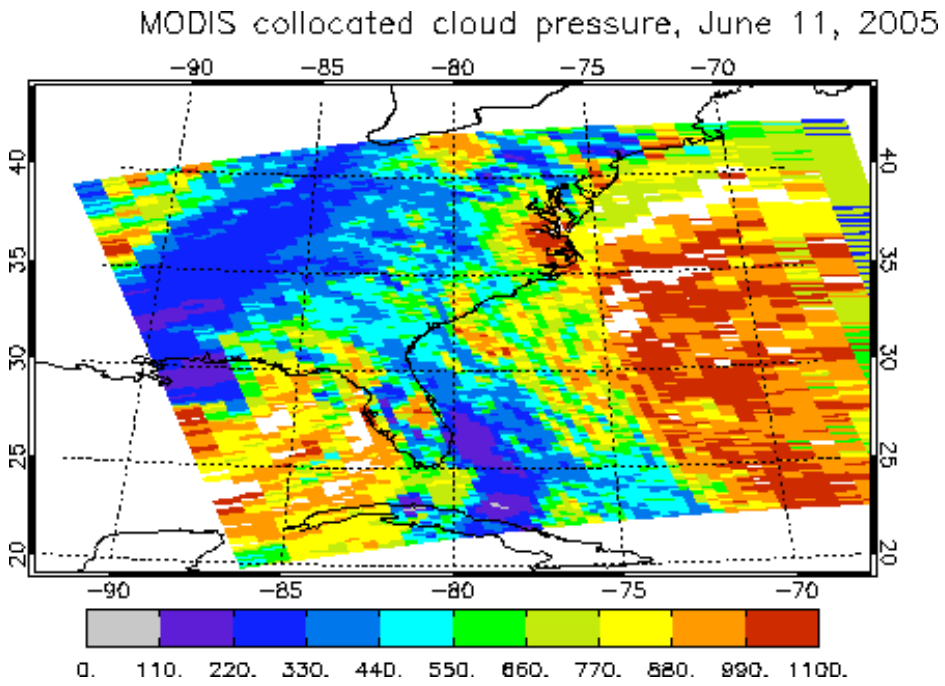
OMI Reflectivity and MODIS Cloud-Top Pressure

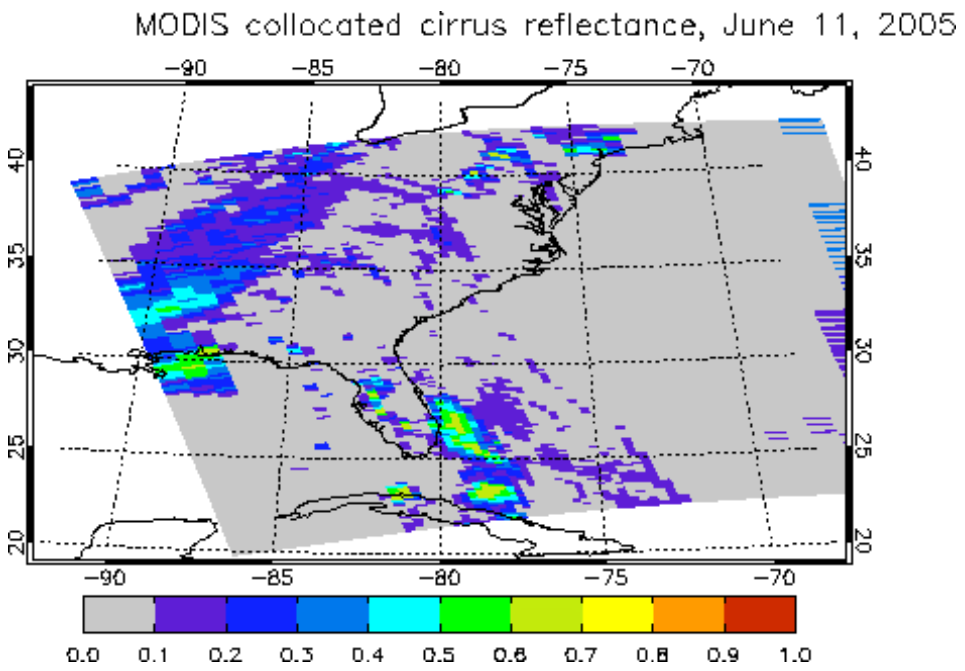




Two high reflectivity (refl > 0.8) areas are seen: over land (Alabama and Mississippi) and ocean (off Florida). We will focus on those areas. Very high clouds (p < 200 hPa) are observed for those areas.

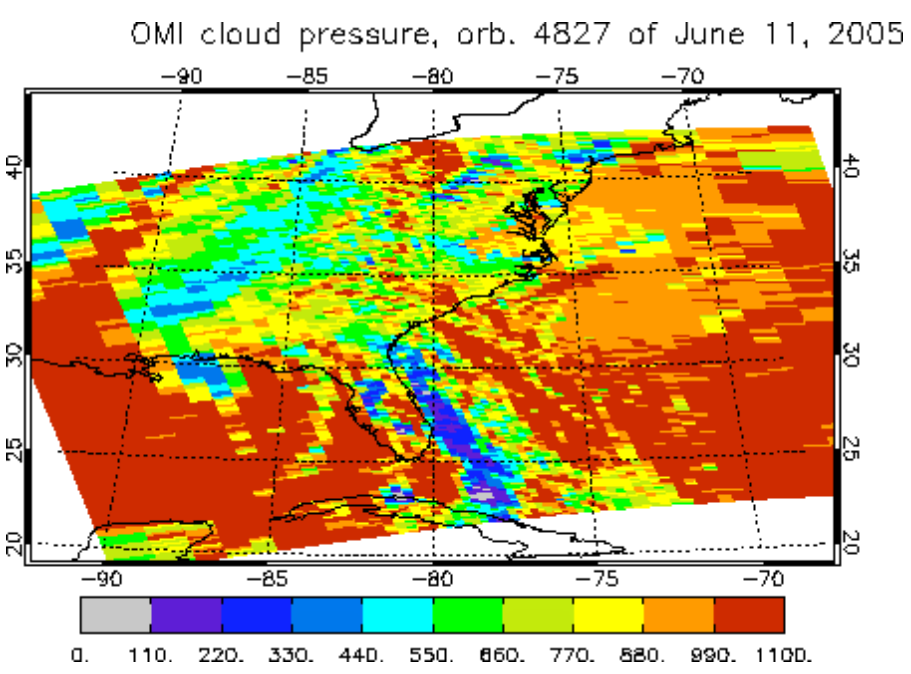
MODIS Cloud-Top Pressure and Cirrus Reflectance

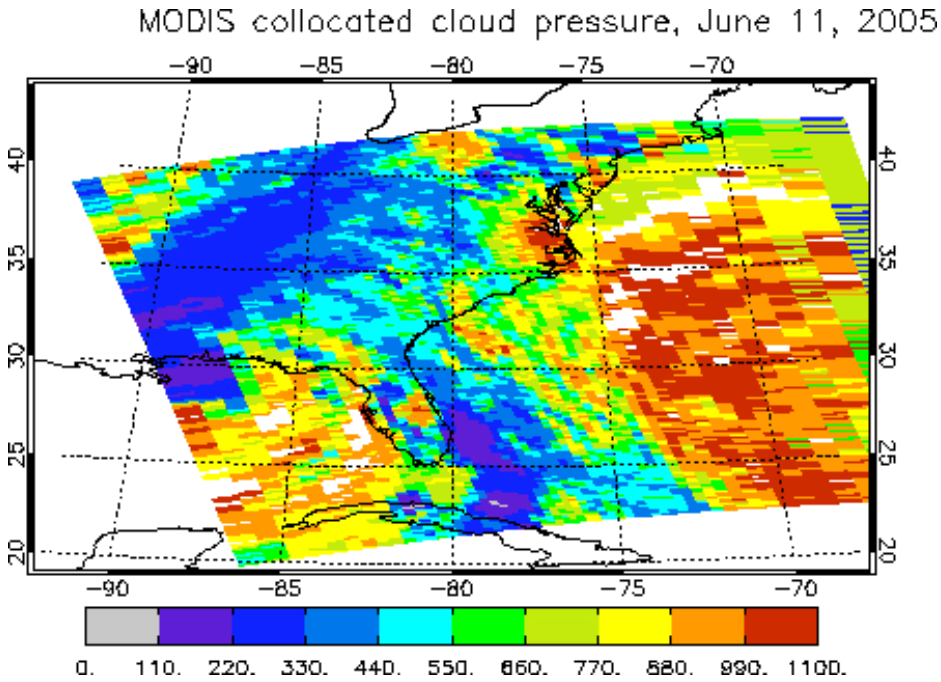




Cirrus reflectances are high for clouds at the center of tropical storm Arlene and off the east coast of Florida

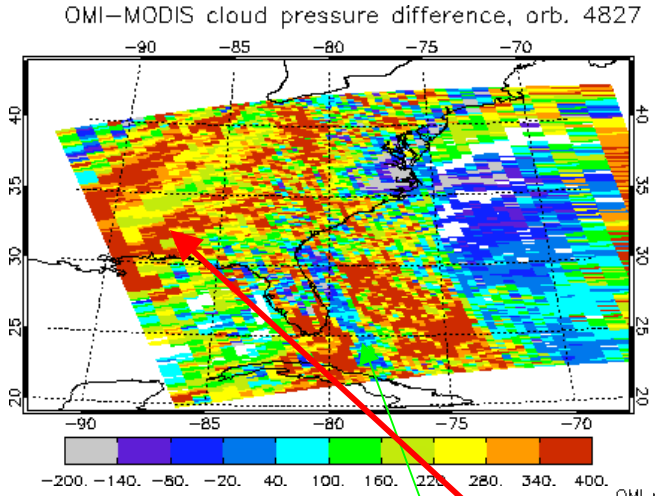
OMI RRS and Collocated MODIS Cloud Pressures



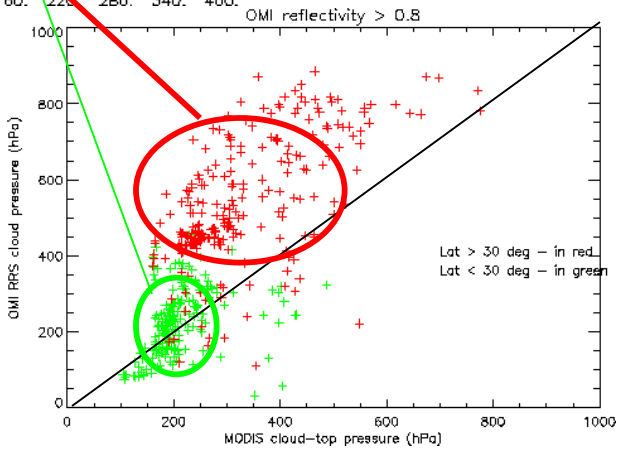


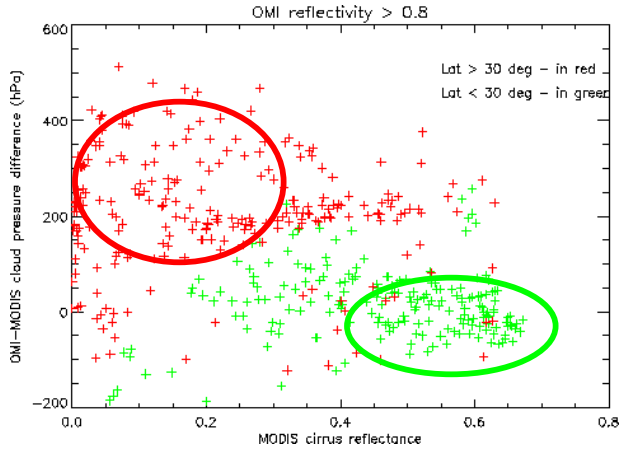
Patterns in the spatial distribution of OMI and MODIS cloud pressures are similar. However, there are big differences for some regions.

High Reflectivity/Altitude Clouds



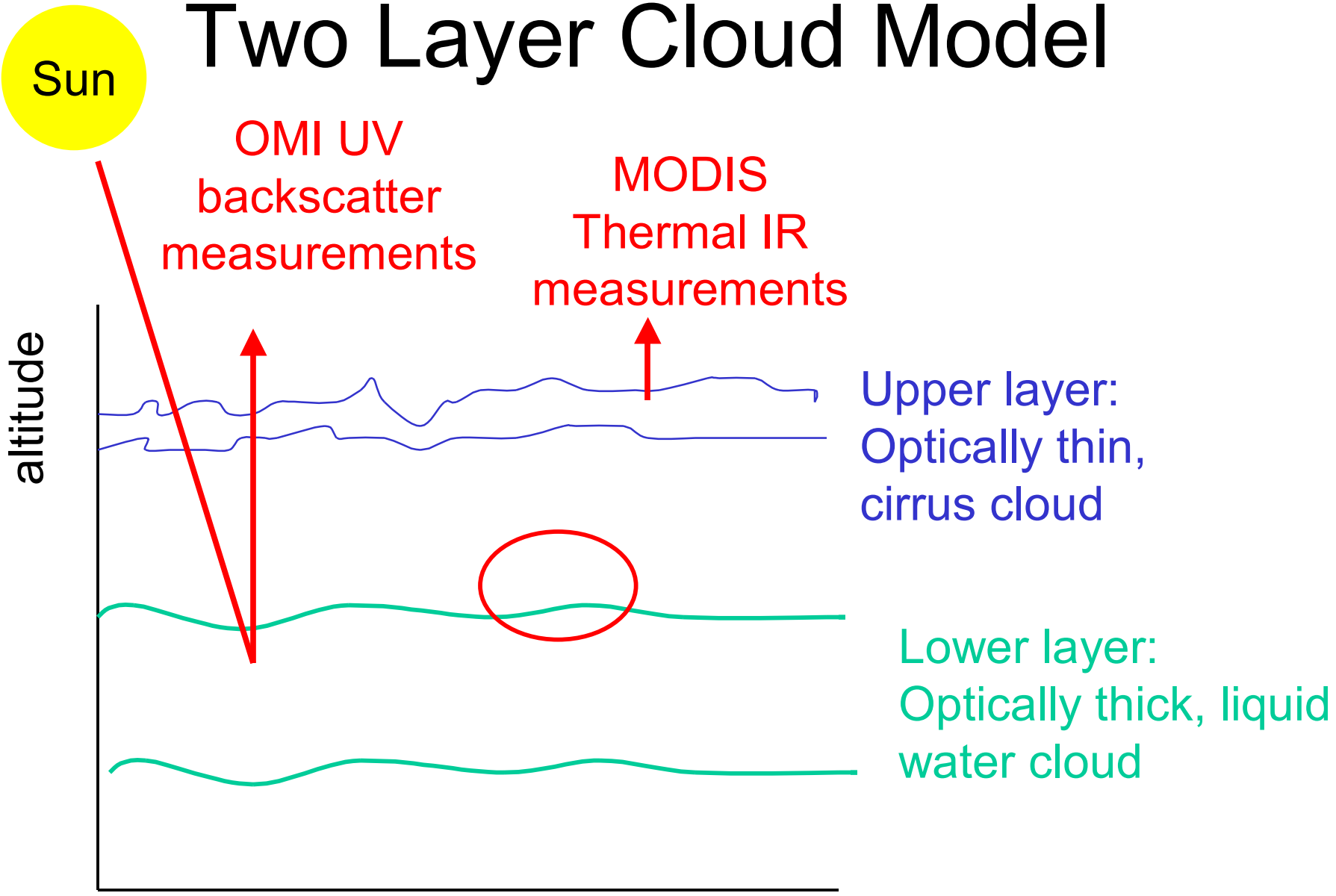
OMI-MODIS cloud pressure differences: Very small differences for clouds over the ocean East of Florida and as high as 300 hPa for clouds over land north of Gulf coast.





Two distinct clusters of pixels are observed (off Florida – green, over land north of Gulf coast – red). A hypothesis is that two distinct layer clouds (thin ice clouds over lower water clouds) produce big differences, whereas deep convective clouds produce smaller differences.

Two Layer Cloud Model



Hurricane Katrina (Aug. 28, 2005)

Credit:

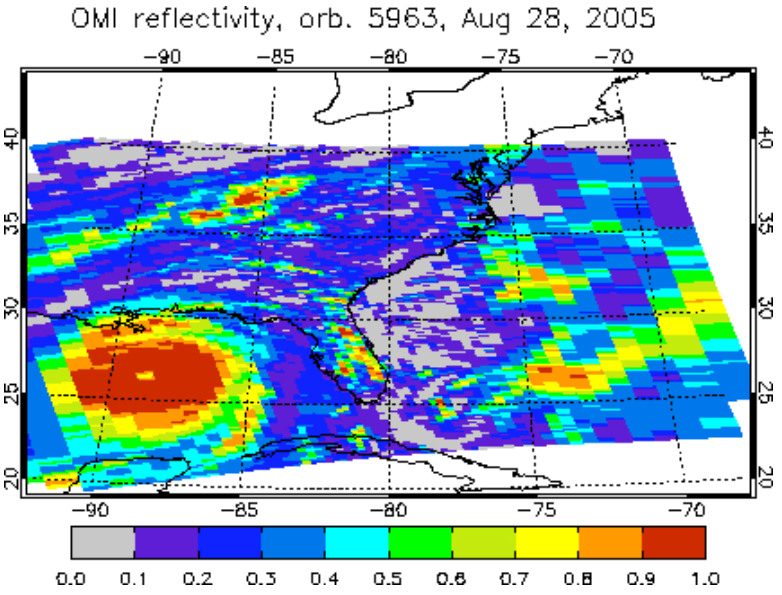
NASA/Jeff Schmaltz,

MODIS Land Rapid Response Team

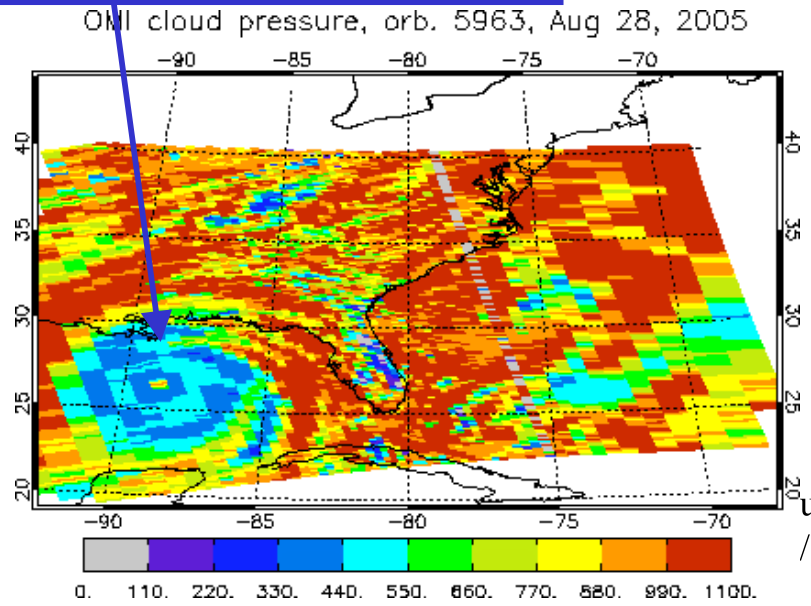
OMI's view of Katrina

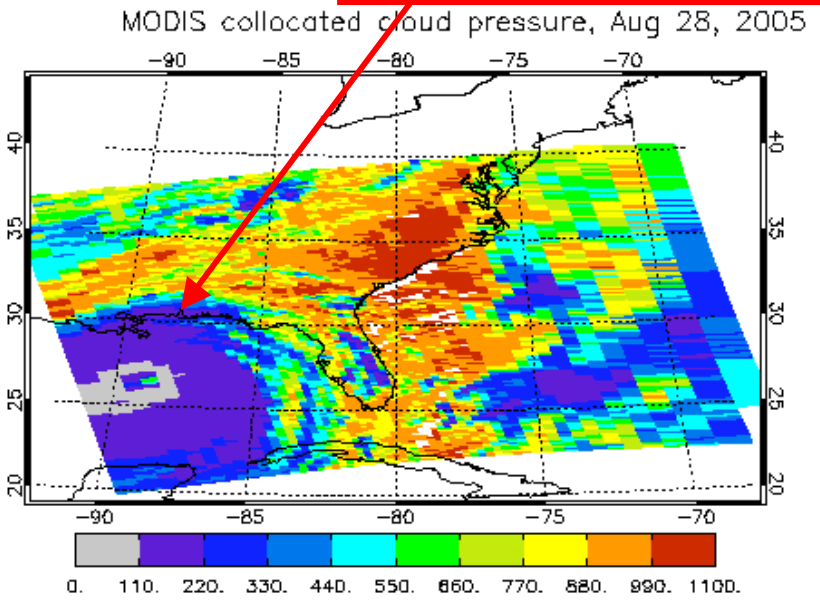
OMI effective cloud pressure: UV channels sensitive to Raman scattering see through high cirrus to lower water clouds with band structure

OMI reflectivity

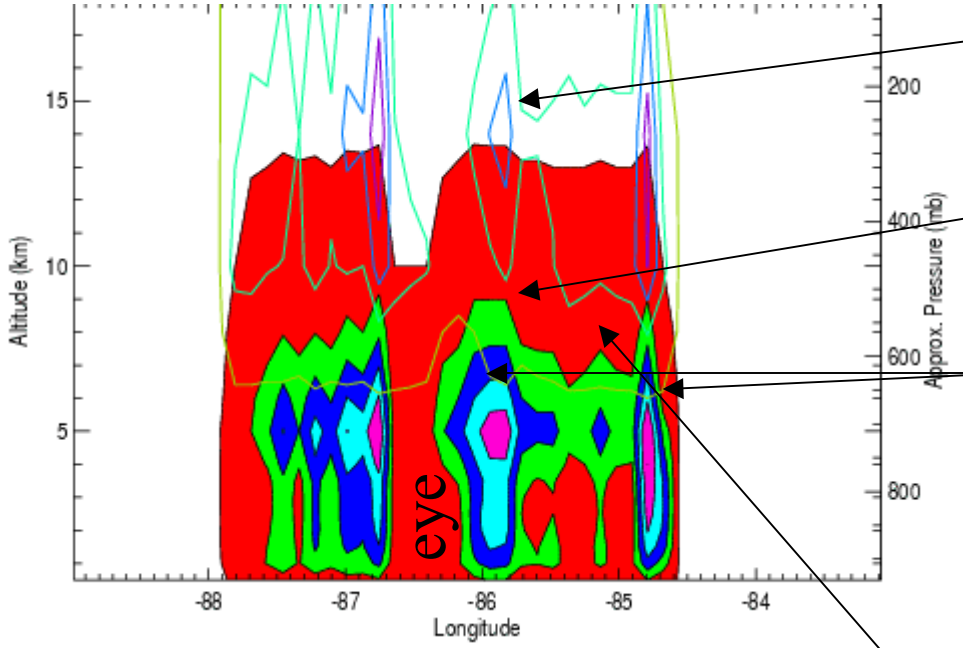


MODIS collocated cloud top pressure: Infrared channels primarily see highest cirrus clouds



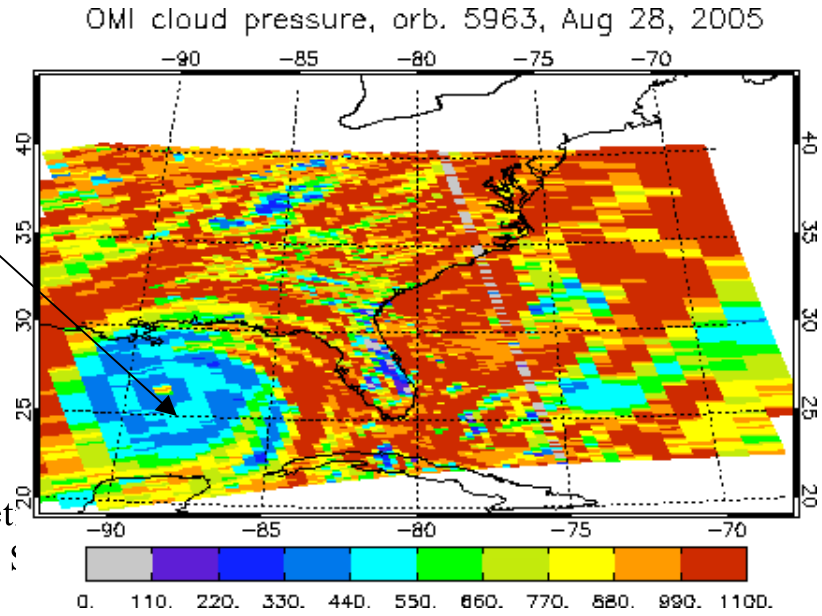


TRMM cross-section through Katrina a few hours earlier



- Solid lines show contours of cloud ice concentration
- Filled colors show contours of cloud liquid water conc.
- Spiral band structure is seen in both the ice and liquid water clouds

In drier areas of subsidence, OMI appears to see through thin ice cloud and retrieves cloud pressures are closer to the pressure of the water clouds



Conclusions

- On average, OMI retrieves higher cloud pressures than MODIS.
- The OMI-MODIS cloud pressure differences depend on the type of clouds: differences for high reflectivity clouds (R>80%) can be small for deep convective clouds and large (~300 hPa) for 2 layer-type clouds
- Large differences appear to be related to thin cirrus clouds which do not significantly affect the OMI in the UV, but are absorbing/detectable in the IR.
- In water clouds, the smaller differences between OMI effective cloud pressures and MODIS cloud-top pressures are explained by penetration of solar light into clouds in the UV (radiative transfer calculations).

Future and Ongoing Work

- Further validation/evaluation of RRS cloud pressures using
  - Radiative transfer calculations with cloud-water and –ice from the Tropical Rainfall Measuring Mission (TRMM) satellite's Precipitation Radar
  - Using TRMM to see where there are ice clouds over water clouds
- Comparison with reprocessed NASA/Cloud Physics Lidar (CPL) data (can see through thin cirrus to lower water clouds)
- Validation with Cloudsat when data are available